CHEM 2110 **TEST 2** **12 APRIL, 2012**

Chemistry for Medicine

Name: MODEL ANSWERS **ID Number:** _____

Time: 1½ hours

Useful constants: $N_A = 6.022 \times 10^{23}$ mol^{-1}

1 amu = 1.6605×10^{-24} g

1 atm = 760 torr = 760 mmHg

Vapour pressure of $H_2O(l)$ at 23 °C = 21.0 torr

$R = 0.08206$ L atm K^{-1} mol^{-1}

1 **H** 1.008																	2 **He** 4.003
3 **Li** 6.941	4 **Be** 9.012											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.88	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
55 **Cs** 132.9	56 **Ba** 137.3	57 **La*** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.9	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** 226	89 **Ac**† (227)															

QUESTION	SCORE	MAXIMUM MARKS
1		39
2		41
TOTAL		80

QUESTION 1

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(a) Write the **name** of each of the following substances:

PI_3	Phosphorus triiodide
$(CH_3COO)_2Pd$	Palladium(II) acetate
NiTe	Nickel(II) telluride
$Ba(BrO)_2$	Barium hypobromite
^2H	Deuterium
$HBrO_2(aq)$	Bromous acid
$H_2O(g)$	Water vapour
TiC	Titanium(IV) carbide
$FeF_3 \cdot H_2O$	Iron(III) fluoride monohydrate
CsO_2	Caesium superoxide
$NH_4V(SO_4)_2 \cdot 11H_2O$	Ammonium vanadium(III) sulfate undecahydrat
Sn_3As_2	Tin(II) arsenide

(b) Write a formula or symbol for each of the following substances:

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Magnesium permanganate hydrate	$Mg(MnO_4)_2 \cdot xH_2O$
Cadmium cyanide	$Cd(CN)_2$
Aluminum hydrogen phosphate	$Al_2(HPO_4)_3$
Chromium(III) chlorate	$Cr(ClO_3)_3$
Aqueous ammonia	$NH_3(aq)$
Ozone	$O_3(g)$
Cobalt(II) carbonate	$CoCO_3$
Superoxide ion	O_2^-
Silver chromate	Ag_2CrO_4
Antimony	Sb
Indium(III) nitrate pentahydrate	$In(NO_3)_3 \cdot 5H_2O$

(c) Write an **equation** for each of the following chemical and physical processes and give a **name** for the process. 16

Example:

Sodium loses an electron when it reacts

Equation: $Na \rightarrow Na^+ + e^-$

Name: Oxidation half reaction

(i) Zinc metal reacts with acetic acid in aqueous solution

Equation: $Zn(s) + 2CH_3COOH(aq) \rightarrow (CH_3COO)_2Zn(aq) + H_2(g)$

Name: Redox reaction

(ii) The reaction of the hydronium ion with ammonia in aqueous solution

Equation: $H_3O^+(aq) + NH_3(aq) \rightarrow NH_4^+(aq) + H_2O(l)$

Name: Acid-base reaction

(iii) Mixing a weak monoprotic acid with water

Equation: $HA(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + A^-(aq)$

Name: Weak acid dissociation/ionization in water

(iv) Burning one mole of solid benzoic acid (C_6H_5COOH) in oxygen

Equation: $C_6H_5COOH(s) + \frac{15}{2}O_2(g) \rightarrow 3H_2O(g) + 7CO_2(g)$

Name: Combustion / Redox reaction

(v) When drops of an aqueous solution of mercury(I) ions are added to a solution of ammonium bromide, a solid product is formed.

Equation: $Hg_2^{2+}(aq) + 2NH_4Br(aq) \rightarrow Hg_2Br_2(s) + 2NH_4^+(aq)$

Name: Precipitation reaction

(vi) When aqueous hydrogen peroxide is heated, water and molecular oxygen are produced.

Equation: $2H_2O_2(aq) \xrightarrow{heat} 2H_2O(l) + O_2(g)$

Name: Thermal decomposition

(vii) Strong UV light breaks the bond in a molecule of chlorine

Equation: $Cl_2(g) \xrightarrow{UV\ light} 2Cl(g)$

Name: Photodissociation

(viii) At room temperature, liquid nitrogen converts to a gas

Equation: $N_2(l) \xrightarrow{heat} N_2(g)$

Name: vaporisation/evaporation

QUESTION 2

8

(a) Consider the reaction of chromium with S_8 to form chromium(III) sulfide.

If 2.00 g chromium reacts with 2.00 g S_8, what mass of the excess reactant remains unreacted?

$$16\,Cr(s) + 3S_8(s) \longrightarrow 8Cr_2S_3(s)$$

$n = \frac{2.00\,g}{52.00\,g/mol}$ $\quad$ $\frac{2.00\,g}{256.5(6)\,g/mol}$

$0.0385\,mol$ $\quad$ $7.80 \times 10^{-3}\,mol$

Choosing limiting reactant:

$\frac{Cr}{16\,mol}$	$\frac{S_8}{3\,mol}$
$0.0385\,mol$	X

$\therefore X_{S_8} = \frac{3\,mol}{16\,mol} \times 0.0385\,mol$

$= 7.22 \times 10^{-3}\,mol$ (required)

$\therefore 7.80 \times 10^{-3}\,mol\ S_8$ is too much

$\therefore S_8$ = excess reactant

Cr = limiting reactant

Mass of S_8 reacted

$= 7.22 \times 10^{-3}\,mol \times 256.5(6)\,g/mol = 1.85\,g$

Mass of S_8 unreacted

$= 2.00\,g - 1.85\,g = 0.15\,g$

(b) Draw a simple diagram that shows **classification** of **pure substances**.

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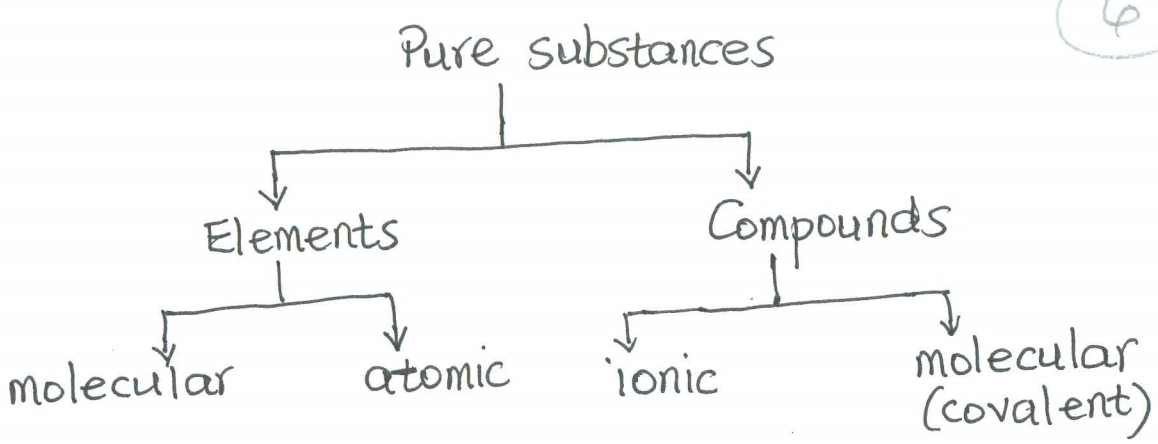

(c) Write a **symbol** for each of the following:

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(i) An atom with mass = 3.1044×10^{-22} g and 112 neutrons.

$3.1044 \times 10^{-22}\,g \times \frac{amu}{1.6605 \times 10^{-24}\,g} = 186.96\ amu$

Isotopic mass = 186.96 amu

Mass number = 187

No. of neutrons = 112

∴ No. of protons = 187 − 112 = 75

∴ Symbol is $^{187}_{75}Re$

(ii) An atom with charge = –2 and 36 electrons.

Charge = −2 ∴ no. of e^- for neutral atom = 34

∴ Symbol = $^{}_{34}Se^{2-}$ or Se^{2-}

(d) Derive a mathematical expression that shows the relationship between the **molar mass** and **density** of a gas.

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$PV = nRT$

$PV = \left(\frac{m}{M}\right)RT$

$PM = \left(\frac{m}{V}\right)RT$

$PM = dRT$

$M = \frac{dRT}{P}$ or $d = \frac{PM}{RT}$

(9)

(e) A flask with a volume of **750. mL** contains a mixture of the gases $NX_3(g)$ and **argon** at **27.85 °C**. The mass of $NX_3(g)$ in the flask is **0.3664 g**. The total pressure exerted by the mixture of the gases is **646 mmHg**.

If the mole fraction of **argon** is **0.800**, identify the gas $NX_3(g)$.

Volume of flask $= 750. \times 10^{-3}$ L

$T = 27.85 + 273.15 = 301.00$ K

$P_T = \frac{646 \text{ mmHg}}{760 \text{ mmHg/atm}} = 0.850$ atm

$P_T V = n_T R T$

$\therefore n_T = \frac{P_T V}{RT} = \frac{0.850 \text{ atm} \times 750. \times 10^{-3} \text{ L}}{0.08206 \text{ L atm K}^{-1}\text{mol}^{-1} \times 301.00 \text{ K}}$

$= 0.0258$ mol

Mole fraction of Ar $= 0.800$

$\therefore \chi_{NX_3} = 1.000 - 0.800 = 0.200 = \frac{n_{NX_3}}{0.0258 \text{ mol}}$

$\therefore n_{NX_3} = 0.200 \times 0.0258$ mol

$= 5.16 \times 10^{-3}$ mol

$m_{NX_3} = 0.3664$ g

$\therefore M_{NX_3} = \frac{m}{n} = \frac{0.3664 \text{ g}}{5.16 \times 10^{-3} \text{ mol}} = 71.0$ g/mol (7)

$\therefore 14.01 + 3X = 71.0$

$3X = 56.9(9)$

$X = 19.0$

$\therefore$ atomic mass of X $= 19.0$ amu (2)

$\therefore$ X is F

$\therefore NX_3 = NF_3$

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(f) When **$KClO_3(s)$** is heated, **$KCl(s)$** and **$O_2(g)$** are produced.

An impure sample of $KClO_3(s)$ weighing **2.76 g** is heated in a room at **23 °C** and **743.0 torr**. **767 cm^3** of oxygen gas is collected over water at **23 °C**.
Determine the percentage composition of **$KClO_3(s)$** by mass in the **impure sample**.

$$2\,KClO_3(s) \xrightarrow{\Delta} 2\,KCl(s) + 3\,O_2(g)$$

$V = 767 \times 10^{-3}\,L$

$P_T = P_{H_2O} + P_{O_2}$

$743.0\ torr = 21.0\ torr + P_{O_2}$

$\therefore P_{O_2} = 743.0\ torr - 21.0\ torr$

$= 722.0\ torr$

$= 0.9500\ atm$

$T = 23 + 273.15 = 296\ K$

$$n_{O_2} = \frac{PV}{RT} = \frac{0.9500\ atm \times 767 \times 10^{-3}\,L}{0.08206\ L\ atm\ K^{-1}mol^{-1} \times 296\ K}$$

$= 0.0300\ mol$

$KClO_3$	O_2
2 mol	3 mol
x	0.0300 mol

$$\therefore x = n_{KClO_3} = \frac{2\ mol}{3\ mol} \times 0.0300\ mol = 0.0200\ mol$$

$\therefore$ mass of $KClO_3 = nM = 0.0200\ mol \times 122.55\ g/mol$

$= 2.45\ g$

$$\therefore \%\ KClO_3 = \frac{2.45\ g}{2.76\ g} \times 100\% = 88.8\ \%$$